II. *On the Geology of the ALTAI MOUNTAINS.* By M. de TCHIHATCHEFF.

[Communicated at the meeting of the French Geological Society at Chambéry in 1844.* Vide *Bul. de la Soc. Geol. de Fr.* 2me ser. tom. i. p. 674.]

THE district of the Altai mountains, as described by M. Tchihatcheff, is situated in Central Asia, between latitude 49° and $52^{\circ} 30'$ N., and longitude 79° and $86^{\circ} 20'$ east of Paris, and is described as extending for about 500 miles in one direction, by 220 in the other. It abounds in lofty mountain peaks, and is traversed by vast rivers, the length of whose course is only surpassed by that of the Amazons, and the Mississippi in America, the Yang-Tse in Eastern Asia, and the Nile in Africa. Of these rivers the Ob is the principal, and it is fed by a number of very considerable streams, almost all of which exhibit a striking contrast in the relative level of their two banks, the height of the right bank being considerably greater than that of the left.†

The direction of the principal streams which traverse the Altai district exhibits a general agreement with that of the mountain chains, and also with the strike of the different groups of strata. Combining the observations that have been made with regard to these points, the whole tract may be subdivided into two districts, the western and the eastern, the former extending between the river Ob and the northern zone of the river of Katoune, in which the prevailing direction of the mountain chains is N. W. and S. E., and the latter including the central and southern district of the river of Katoune, and extending to the borders of the Sayanes, the direction of the mountain chains in it gradually altering from that in the former district, and terminating by running from N. E. to S. W. It is interesting to find that this change in the direction of the mountain chains is accompanied by marks of disturbance in the folds and contortions of rocks, and by the appearance of curved and broken lines of high ground, which are very strikingly shown, and are, indeed, evident by a mere glance at the map of the district. In the steppe of Tchouya this arrangement of a series of heights in the form of a natural amphitheatre takes place in rocks composed of clay slate, and all the masses, shaped into the form of gigantic craters, or of lofty crests, folded as it were back upon one another, and strikingly resembling the configuration of igneous

* The observations of M. Tchihatcheff, the results of which were communicated in this notice to the French Geol. Soc., were also offered to the Academy of Sciences, and a report on the subject by Messrs. Brongniart, Dufresnoy, and Elie de Beaumont appears in the "*Comptes Rendus*" of the 12th of May (vol. xx. p. 1389). We learn, also, from a late number of the *Bulletins de la Soc. Geol. de France*, that M. Tchihatcheff has now published his great work, of which the outlines are here given. — ED.

† This is the case too with the rivers in Northern Siberia, and also with the Volga and others of European Russia. See "*Russia and the Ural Mountains*," by Mr. Murchison, M. de Verneuil, and Count Keyserling, vol. i. p. 650. — ED.

rocks, are also in fact enormous sedimentary deposits more or less metamorphosed. It appears to be the case that one of the prevailing features in the general contour of the Altai consists not only in a terrace-like arrangement of the great masses which compose it, but also in a certain rounded or swelling outline of these terraces, suggesting the agency of plutonic forces beneath the surface, sufficient to produce these undulations of the sedimentary crust and the frequent metamorphism, but often without leaving any marks of violent disturbance or disruption, and without the presence of igneous rocks at the surface to account for the alterations that have taken place.

The more ancient rocks of the Altai present, in some places, the apparent anomaly of perfectly horizontal stratification, immediately adjacent to indications of disturbance more or less violent, and one result of this, especially in the eastern part of the district, is recognised in the absence of bold and picturesque outlines, and the prevalence of those smooth rounded contours and straight lines which fatigue the eye of the traveller, and which may be compared with the appearance of the well-known Sierra Nevada of Spain, probably produced by the same geological structure, and exhibiting the same character along a line upwards of 120 miles in length, presenting a strikingly dreary and monotonous appearance. The districts of this kind in the Altai consist, as in Spain, of a long ridge with a flattened summit composed of horizontal beds not accompanied by any rocks of decidedly plutonic origin, but composed of mica schist and clay slate passing into chloritic schist, all probably of the older palæozoic period.

The structure of the Altai district, as indicated by the direction of the mountain chains, is fully confirmed by geological investigations concerning the strike of the different beds; those in the western district running N. W. by S. E., and those in the east at right angles to this direction. Where these two lines of elevation cross one another we may remark on the one side that kind of interlacing and entanglement by which the system of the Saïansk is almost everywhere confounded with that of the Altai, properly so called, and on the other side the considerably greater altitude of the mountains of the eastern compared with those of the western district. The highest point of the Altai range is precisely in the intersection of these two axes of elevation, and the lake of Teletzk in the immediate vicinity of the intersection is also due in all probability to the same geological causation. The eastern Altai is, however, remarkable for the number of lakes of great depth which abound in it, while, with the exception of the celebrated Lake of Kolyvan, the western district contains few worthy of note until we reach in its western extremity those singular salt lakes which belong to a different group of geological phenomena. The date of the elevation of the western Altai seems, from some appearances, to have been contemporaneous with that of the Ural.*

* With reference to this subject the author in the *résumé* quoted, offers some

The plutonic rocks of the district under discussion consist of granite, syenite, quarziferous porphyries, eurites and melaphyres, the mutual relations of which, though often difficult to make out, seem to lead to important conclusions with reference to the sedimentary deposits, almost all of them in fact being more modern than these latter, and proving, by their relations with the metamorphic rocks, that none of the igneous rocks of the Altai are in the strict sense of the word "primary," or in other words, portions of the original solidified crust of the globe.

Rocks of mechanical origin occupy the greater part of the Altai district, and with the exception of some diluvial deposits, they all appear to belong to the older or palæozoic series. I have been able to determine positively the following groups, viz.:—*a.* Devonian formations; *β.* carboniferous limestone; and *γ.* uppermost beds of the coal measures or possibly of the Permian series.

a. Devonian Rocks. Rocks of this period (so far as my investigations, limited certainly to a small part of the whole area occupied by them, enabled me to judge) are distributed in three regions separated from one another by other ancient but non-fossiliferous strata, or more frequently by granitic rocks and diorite. These three regions I have designated the basin of Zinieff, that of Tomsk, and that of the river Yenesei, extending between the mouth of the Ambakaya and the town of Krasnoyarsk. From the two first of these I obtained fossils, of which the following is a list, viz.:—

<i>Calymene macrophthalma</i>	<i>Cyathophyllum turbinatum Goldf.</i>
<i>Terebratula prisca</i> var. <i>explanata</i>	<i>C. hexagonum</i>
<i>T.</i> resembling <i>T. ventilabrum</i>	<i>C. helianthoides?</i>
<i>Spirifer speciosus</i>	<i>C. quadrigeminum?</i>
<i>S. alatus</i>	<i>Petraia celtica Londs.</i>
<i>S.</i> resembling <i>S. Verneuli</i>	<i>Calamopora fibrosa Goldf.</i>
<i>Leptaena</i> , resembling <i>L. lata</i>	<i>C. spongites</i>
<i>Orthis crenistria</i>	<i>C. polymorpha</i>
<i>Producta subaculeata</i>	<i>C. infundibuliformis</i>
<i>Stromatopora concentrica</i>	<i>Retepora retiformis.</i>

together with numerous fragments of *Orthoceratites* and stems of *encrinurites*.

β. Carboniferous Limestone. The carboniferous like the Devonian rocks are grouped in three detached basins, from each of which I have obtained fossils more or less characteristic. The fossils obtained from these basins are the following:—

<i>Orthis arachnoidea</i>	<i>Producta punctata</i>
<i>Spirifer mosquensis</i>	<i>P.</i> resembling <i>punctata</i>
<i>S. trigonalis</i>	<i>Retepora membranacea Phil.</i>
<i>S. Bronnianus</i>	<i>R. retiformis</i>
<i>Producta antiquata</i>	<i>Eschara scalpellum Londs.</i>

conjectures founded on the parallelism, or supposed parallelism, of the Altai, with other known mountain chains. From an answer to an observation made by M. de Verneuil, in the course of the subsequent discussion (also recorded in the "Bulletin") it appears that these conjectures are hardly sufficiently grounded to satisfy even the author himself. — *Ed.*

γ. Deposits, which may be considered as intimately related with those of the carboniferous series and forming the uppermost portion of them, perhaps, indeed, belonging to the group now described as *Permian*, occupy an extensive basin, which I have designated "the basin of Kouznetz," from the city of that name situated near the middle of the district. In this wide extent two localities are especially remarkable by their palæontological characters, namely, the village of Afonina and the banks of the river Inia, and both are especially rich in the trunks of fossil trees, which have been the subjects of investigation by M. Göppert. The following is a list of the different species of vegetable markings and trees found in these deposits : —

<i>Anarthrocanna deliquescens</i> Gæp.	<i>Nœggerathia æqualis</i> Gæp.
<i>Neuropteris adnata</i> Id.	<i>N. distans</i>
<i>Sphenopteris imbricata</i> Id.	<i>Araucarites Tchihatcheffianus</i> Gæp.
<i>S. anthriscifolia</i> Id.	

The probable absence in the Altai district of any deposits more recent than those of the palæozoic period corresponds in a remarkable manner with the similar absence of trachytes, properly so called, of basalt, obsidian, lavas, and generally of all rocks characterising periods comparatively modern. This circumstance not only constitutes one of the most striking distinctive characters between the Altai district and America, Hungary, Turkey in Europe, the Phlegrean fields, the Island of Java, &c., all of which exhibit trachytic rocks and lavas, but it also distinguishes western from eastern Siberia. In fact the great extent of country eastwards from the Yenesei exhibits basaltic rocks, phonolites, trachytes, species of obsidian, perlites and lava currents (as at Kamchatka), associated with secondary deposits not occurring in the Altai. The peninsula of Kamchatka also, which, of all these vast regions, is the one best characterised by modern phenomena of eruption, contains the most recent sedimentary rocks hitherto discovered in Siberia ; since, according to M. Ermann, cretaceous rocks fringe a considerable part of its western shore, and are flanked by a broad band of tertiary deposits. It is, therefore, probable that a part of Eastern Siberia, especially the tract watered by the river Lena, between Yakoutsch and the mouth of the river, including several islands in the Arctic Ocean situated near the mouth, have been elevated more recently than that part of Siberia stretching westwards to the Saïansk mountains. Perhaps hereafter, when our knowledge of Central Asia is less vague, this line may be extended to include the great chain of Thian-Chan, if indeed the cautious policy of China should allow us to examine more closely the volcanic cones and craters, whether recent or still in action, in the western governments of that vast empire.

If, however, in respect of geological age, the greater part of the Altai finds its representatives in the older formations of Asia, Africa, and America, this district is not less strikingly distin-

guished from those countries by some palæontological peculiarities. It is true that the very superficial knowledge that we possess of the fossil flora and fauna of the Altai will not enable us at present to establish a comparison between these few fragments and the great series of fossils found in Europe, but even the little at present known appears to justify the following remarks, although they may hereafter, when we know more of the subject, require some modification.

The genera *Nautilus*, *Goniatites*, and *Posidonia*, so characteristic of the carboniferous limestones of England and the Rhenish provinces, appear to be entirely absent in the analogous deposits of the Altai, and in the same way *Strigocephalus* and *Murchisonia* which abound in the Devonian rocks of the Rhenish provinces, and in Devonshire, have not here left any traces of their existence.

The class of fishes also is absent, or at least is by no means so characteristic as in other Devonian districts.

Now it would seem that with regard to the rarity of *Cephalopoda*, the old rocks of the Altai offer analogies rather with America than with Europe, since, according to the Count d'Archiac and M. de Verneuil*, these fossils were much less abundant in the ancient American than in the European seas. The Altai however is far behind even the former in this respect, for there have only been found at present, so far as I am aware, *Goniatites Henslowii*, *G. Listeri*, *G. carbonarius* and *G. sphaericus*, fossils extending over an immense area, some of them occurring in various parts of Europe and in the United States, and even in India, according to M. Von Buch, who has found *G. Listeri* on the banks of the Ganges. The genus *Orthoceratites* is also rare in the Altai, compared not only with its abundance in the ancient formations of Europe, but even in America, where the fewness of the species appears to be made up by a greater variety of generic forms.

It would seem to result from the preceding observations that, at the period of the deposit of the palæozoic rocks of the Altai, the sea presented a well-marked difference in the nature of the pelagic fauna, distinguishing it in this respect from all the contemporaneous seas. This difference has stamped the fauna with a peculiar character, which at the present day is to be observed in northern seas, as compared with those of the temperate and tropic zones, namely, 1. poverty in the number of orders, genera, and species; 2. great relative abundance of individuals; and 3. certain restrictions in the development of individual forms, compared with their congeners of warmer countries.

These three peculiarities seem in fact combined in the Altai fossils, for they are not only remarkable for the fewness of the genera and species, but also by a certain reduction in external dimensions, so that enormous masses of rock appear to be made up of a vast multitude of small fossils, the larger analogous forms of the Cephalopodous and Brachiopodous families failing entirely, and

* Geol. Tr. 2d ser. vol. vi. p. 329.

being only replaced by these minute representatives. The only apparent exceptions to this general condition are seen in the animals of lowest organisation, such as the species of *Calamopora* and *Cyathophyllum*.

The examination of the fossil flora of the Altai (although at present confined to the specimens brought by myself from the carboniferous rocks) appears to conduct us to results of the same kind as those arrived at by the investigation of its fossil fauna. Among the numerous trunks of fossil trees and vegetable impressions collected from the extensive carboniferous basin of Kouznetzky, we may trace a poverty of generic and specific types, compared with the fossil flora of contemporaneous formations in Europe and America, although the specimens examined almost all belong to new species. Those that have been described again are mostly referred to *Coniferae*, in so far therefore exhibiting a tendency to approximate to the condition of existing creation, and indicating a less tropical flora than that of other countries during the same epoch. Whilst indeed the carboniferous rocks of Europe and America contain a multitude of the remains of plants, such as *Lepidodendron*, *Sigillaria*, &c., whose nearest analogues are to be sought at the equator, the same rocks in the Altai are more especially characterised by species which, like *Araucarites*, present the greatest analogy, if not a perfect identity with plants which still form immense forests beyond the tropics, the *Araucaria* not only abounding in New Holland, but attaining in Norfolk Island gigantic dimensions, not inferior to those of the largest specimens found in a fossil state.

The Altai district therefore, whether considered with reference to the direction of its mountain chains and other physical features, or with regard to its fossils, appears to have little relation with the geological formations of Europe and America. Differing, also, not less from the mountain district of European Russia, the vast expanse of Western Siberia is as it were isolated, and claims in its geological description a separate consideration, destined perhaps some day to be connected with investigations concerning the geological constitution of northern and central Asia.

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